JEKYLL AND HYDE IN A TANK: THE DILEMMA OF TASK FORCE BATTLE COMMAND FROM A KILLING SYSTEM

A Monograph
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This monograph examines the U.S. Army's concept for its Future Main Battle Tank (FMBT) as a battle command vehicle for the armored task force commander. The monograph first presents the elements of battle command from the armored task force commander's perspective. The study examines the commander's leadership, decision making, and force control requirements separately and as they impact on each other. The study uses the resulting framework to assess the adequacy of a model FMBT's design with respect to the needs of the commander. The monograph next presents a model FMBT in terms of four fundamental parameters of design: lethality, survivability, mobility, and sustainability. Current and emerging technologies of the next ten to fifteen years bound the model's design feasibility. The study then analyzes how well the model FMBT meets the commander's battle command requirements. Analysis of the tank's conceptual design in terms of versatility, flexibility, and fightability determines that there is a need for a Commander's FMBT. The study concludes that future production of a multifunctional FMBT is possible given its modular crew stations and electronics architecture. Further investigation of the Commander's FMBT concept is necessary and can be done using contemporary research and development tools.

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ABSTRACT

JEKYLL AND HYDE IN A TANK: THE DILEMMA OF TASK FORCE BATTLE COMMAND FROM A KILLING SYSTEM by Major James B. Henderson, USA, 55 pages.

This monograph examines the adequacy of the U.S. Army's concept for its Future Main Battle Tank (FMBT) as a battle command vehicle for the armored task force commander. The study scrutinizes the battle command requirements of the armored task force commander from the moral and cybernetic perspectives. Analysis of a model FMBT in terms of the versatility, flexibility, and fightability it provides to the commander reveals the need for a tank specifically designed to meet his leadership, decision making, and force control requirements.

The monograph first presents the elements of battle command from the perspective of the armored task force commander. The study examines the commander's leadership, decision making, and force control requirements separately and as they impact on each other. The result is a framework that the study uses to assess the adequacy of the model FMBT's design with respect to the needs of the commander. The framework also provides a comprehensive model that combat developers can use as a reference when developing requirements for a future Battle Command Vehicle or Command Group Vehicle.

The monograph next presents a model FMBT in terms of four fundamental parameters of tank design: lethality, survivability, mobility, and sustainability. Current and emerging technologies of the next ten to fifteen years bound the model's design feasibility.

The study then analyzes how well the model FMBT meets the commander's battle command requirements. Analysis of the tank's conceptual design in terms of versatility, flexibility, and fightability required by the commander determines that there is a need for a Commander's Future Main Battle Tank.

The study concludes that future production of a multifunctional FMBT is possible given the flexibility of its modular crew stations and electronics architecture. Further investigation of the Commander's FMBT concept is necessary and can be done using several contemporary research and development tools. Refinement of the concept will provide detailed definition of the requirements for a Commander's FMBT so that combat developers can revise existing requirements documents to reflect this need.

TABLE OF CONTENTS

I. INTRODUCTION

> If a satisfactory mount for the commander of a mechanized force has so far been found, I have not encountered it personally or vicariously.[1]

Since the emergence of the tank on the battlefields of Europe during World War I, armor leaders at levels battalion and below have exercised battlefield leadership from a vehicle designed to add lethality, mobility, and protection to land warfare. The tank's impact on these three characteristics of warfare is arguably greater than any other weapon system developed over the same era. Undisputed, however, is the effect of the tank on battle command, particularly at the level of the armored task force commander.[2]

In the 1930s, the proliferation of wireless radio sets in British tanks led to improved communication and coordination in armor units. The limited range of wireless radio required the commander to have mobility and protection equal to that of the unit.[3] The vehicle that immediately fulfilled these requirements was the tank. The tank concurrently presented challenges to the commander. Limited work space and the added responsibilities as a tank commander, such as maneuvering the tank and controlling its fires, compounded the already complex task of commanding an armor battalion.

The need for mobility and protection created a dilemma for the armor commander. To communicate with his unit and coordinate its actions, the commander had to operate from a tank. The challenges associated with commanding from a tank turret, however, degraded his ability to effectively command the unit. This dilemma still exists today even with a quantum improvement in FM communications over the past 60 years. Today's armored task force commander operates from a tank so that he can move

with and control his force. The tank's mobility and protection allow him to do this. However, for the same reasons as in the 1930s, the armor commander's ability to command his force is diminished by having to do so from a vehicle that is first and foremost a fighting system.[4]

There are two practical solutions to this dilemma. First, the armored task force commander can command from a tank modified to meet his unique battle command requirements. Or second, the commander can operate from a vehicle, not a tank, that is singularly a "commander's/ command group vehicle." There are several problems and considerations inherent in the latter alternative.

Survivability is problematic for a "commander's/command group vehicle (CV/CVG)." The intended widespread use a CV/CVG across a large spectrum of the force (armor and infantry units, brigade level, etc.,) typically results in a unique battlefield signature. A command vehicle's unique signature invites the unwanted attention of almost every enemy killing system. Also, attempts to maximize the crew size and battle command capabilities of the vehicle often yield an unacceptable tradeoff in vehicle protection. This is reflected particularly in the increased amount of passive armor required to protect a larger crew compartment. Effective weapon systems for self-defense are generally inadequate or all together absent.[5] The lack of adequate survivability significantly reduces the commander's freedom of movement on the battlefield.

One must also consider the impact on force structure in fielding a CV/CVG. The Army generally does not field vehicles in unit sets due to the high costs associated with such a strategy. The Armored Systems Modernization (ASM) program is a prime example of a cost prohibitive, but well-intended developmental and fielding strategy for a family of heavy vehicles. Envisioning as many as 30 different armored vehicles for 24

missions, ASM did not survive cost effectiveness analysis, particularly during a time of decreasing procurement budgets.[6]

Conversely, fielding a CV/CVG as part of incremental force structuring runs the risk of creating a gap in vehicle capabilities within the force. The current state of service support vehicles in a U.S. Army armor battalion epitomizes a strategy that prioritizes the fielding of highly capable combat vehicles at the expense of total force efficiency. In fact, this strategy has created incongruent levels of vehicle mobility and survivability among the armor battalion's combat, combat support and combat service support vehicles.[7] The result is a heavy force with an inadequate recovery vehicle, medical and maintenance support vehicles incapable of keeping pace with fighting vehicles, and armor commanders conducting battle command much as they did 50 years ago.

The problems associated with a CV/CVG approach to a "battle command vehicle" leads back to the first alternative, the tank. Can the tank serve as an effective vehicle from which the armored task force commander may conduct battle command? There is some historic precedent to this question.

Before World War II the Germans developed and fielded a *Panzerbefehlswagen* (armored command vehicle) for use by battalion commanders and above. A modified *Panzerkampfwagen III*, the *Panzerbefehlswagen* mounted a dummy cannon on a fixed turret, contained up to six radios in the command compartment, had a map table and several cushioned seats with backrests, and had additional vision ports. In 1943 the Germans replaced its distinct loop antenna with conventional rod antennas to reduce vehicle signature.[8]

The Israelis have also recognized the need for a tank modified to meet the armored commander's battle command requirements. The front

mounted engine design of the Merkava III tank provides enough space in the rear of the vehicle for up to 10 troops, four litters, or a small command group.[9] With this design, the command group version of the Merkava III retains all the survivability, mobility, and lethality characteristics of the mainstay Merkava III main battle tank.

Like the Israelis, the U.S. Army saw utility in modifying its main battle tank to facilitate the commander's battle command requirements. Modifications to the M60A3 and M1 tanks by the U.S. Army Armor and Engineer Board in the 1980s, however, were based more on facilitating command techniques as opposed to investigating and meeting the commander's battle command requirements. Problems in technical design and unreliable equipment tabled further modifications and investigation into the tank as an effective battle command vehicle.[10]

With the delay of the Future Main Battle Tank Program, and the apparent potential of emerging battle command related technologies, the Army faces a key opportunity to look at the tank as an adequate battle command vehicle for the armored task force commander. At issue is a need for a Future Main Battle Tank (FMBT) designed to meet the future battlefield requirements of the armored task force commander. In other words, does the Army's vision for the FMBT meet the commander's battle command requirements? If not, then should the Army modify the concept for the FMBT in order meet his requirements?

The purpose of this paper is to determine the armored task force commander's theoretical battle command requirements. Section II examines the requirements from the moral and cybernetic domains of the battlefield, and the threefold interrelationship of leadership, decision making, and force control. Section III presents a "model" Future Main Battle Tank using the same design parameters that U.S. Army Armor Center combat developers

use to articulate requirements for the FMBT. Section IV analyzes the ability of the FMBT to meet the commander's battle command requirements. Analysis centers on the trade-offs in design necessary to provide the commander the flexibility, versatility, and fightability he requires for battle command. The principal findings and conclusions are summarized in Section V along with a recommendation for a possible strategy in refining the commander's unique requirements for a "Commander's FMBT."

II. BATTLE COMMAND: THE ARMORED TASK FORCE COMMANDER

> The battalion commander holds the most important job in the army. His command is the essence of tactical command. [He] is the closest senior leader to see and fight the battle. He synchronizes decisive combat power at the forward edge of the battle ... [by] skillfully employing the dynamics of maneuver, firepower, and leadership .... .[11]

According to U.S. Army Field Manual 100-5, Operations, *command* is the art and science of motivating, directing, and controlling soldiers and organizations. The goal the commander seeks is mission accomplishment. To achieve this, the commander must visualize the physical arrangement of the battlefield in terms of time, space, and friendly and enemy forces. He directs forces into action, and then controls them as they execute his operational concept.[12]

Flexibility is a fundamental aspect of command. A commander can neither cope with constant guidance from his higher commander, nor can he provide continuous direction to his subordinates. The commander must be able to choose not only how he commands his unit, but also from where he will command it. These choices are largely a result of the personality of the commander. There are, however, limitations that he must consider when exercising command. The training and operational readiness of the unit, and the communications and computing technologies that form the commander's "battle command system," are variables in the battle command equation.[13] It is the ultimate responsibility of the commander to ensure that his method of command does not exceed the reasonable limits of these variables. Similarly, the military must support the commander with the equipment he needs to perform battle command.[14]

To provide the necessary equipment, the military must first understand the armored task force commander's battle command needs. This requires a comprehensive view of his battle command requirements not only for enhanced communications and computing systems, but also of his desire to exercise a flexible, personal method of command. Analyzing battle command from its moral and cybernetic domains provides the comprehensive view we seek.

The U.S. Army's Field Manual 100-5 (Operations) states that *leadership, decision making, and controlling the force* (force control) are the three fundamental and intrinsic elements of battle command.[15] Each element has its own separate characteristics. However, as Figure 1 depicts, all three continuously interact upon each other.

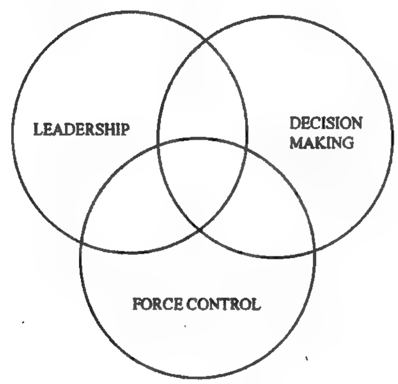


Figure 1. Elements of Battle Command

For instance, in order to make sound decisions in combat, the armored task force commander must have timely and accurate information. He obtains some of this information from his staff, operating principally in the force control realm, and its analysis of the enemy and friendly situations, the combat effectiveness of the unit, and many other critical information requirements. Battle command is a system of elements continuously and simultaneously at work, with none of the elements totally independent of the

others.[16] Linkages exist between each element so that failure or improvement in one element may have a cascading effect on the other two.

Leadership is the most decisive determinant of success or failure on the battlefield.[17] At the armored task force command level, leadership is an element of combat power that can decide victory.[18] Military leadership is an art encompassing the influence of the commander over others so that they will take action and accomplish unit missions. The armored task force commander uses leadership to provide direction and purpose to his subordinates. He motivates and inspires soldiers to do the seemingly impossible under the most adverse conditions.[19] To be able to do this, the commander must have four key qualities or characteristics: *courage, will, audacity, and presence.*[20]

To be an effective leader the armored task force commander must have both moral and physical courage. As a leader, he often influences his soldiers to risk their lives to achieve a greater end that they may not readily perceive.[21] To affect soldiers in this way requires the moral courage to demand that they do what appears to be unreasonable, their actions all the while falling within the commander's plan to accomplish the mission.

Because he typically commands at the front, the commander also requires physical courage. Personal courage and training allow the commander to temper his fear while sharing his soldiers' dangers and hardships. He is then better able to understand their needs and capabilities. The commander's displays of courage and personal example serve as effective motivational tools. The calm and collected demeanor of the task force commander on the radio often helps the unit remain focused on its task. Soldiers who sense and see their commander with them in battle will believe in their commander and will fight for him.[22]

Another leadership quality of the armored task force commander is will. War is a contest of weapons and will power between adversaries. Success is often based on unwavering fidelity toward accomplishing the mission. The successful commander is he who is more resolute and firm at the point in combat when all the unit's resources are fully engaged.[23] The commander's will is often based on an innate endurance to overcome resistance by the enemy or battlefield friction. During combat he uses battlefield position and radio or face-to-face communications to express his will to win and to ensure that it is acted out by his subordinates.

Audacity is often an expression of the commander's will to achieve victory. The armored task force commander works under a guiding principle that the bolder decision is the correct one when the tactical situation is in doubt or is extremely difficult.[24] The commander must understand when and where he is taking risk; however, he should not allow it to hold him hostage. The audacity of the commander is predicated on his successful calculation of risk and a determined courage to overcome indecision. Tentative execution of a plan of action courts disaster and defeat.

The commander's presence on the battlefield is a fundamental characteristic of leadership. S.L.A Marshall described the critical nature of command presence when he stated that:

> The need that a commander be seen by his men in all of the circumstances of war may therefore be considered irreducible. Not to exercise that privilege is to deny his command an additional measure of moral strength which may not be gained in any other way.[25]

The armored task force commander must be capable of making his moral and physical presence felt as he moves about the battlefield. Leading from the front has a great impact on how soldiers view the commander and thus has an impact on their performance. The armor force has perhaps no

better example of this precept than that of Lieutenant Colonel Creighton Abrams during World War II. Abrams always commanded his battalion from positions far forward and often participated in the fighting. But the destruction that he individually wrought on the enemy was not the critical aspect of his personal method of command. Instead, it was the motivational effect of his example on his men.[26]

Today, armored task force commanders continue to command from the front. However several features of the battlefield, today and in the future, complicate the ability of the commander to participate in the fight much as did General Abrams. The increased operational tempo and unprecedented lethality of the battlefield, the emerging revolutionary tools for the commander to improve his situational awareness, and greater access to more accurate, timely information will challenge the battlefield commander.[27] In question is the balance between the commander's role as fighter and leader. Feedback from armor battalion and cavalry squadron commanders who fought in Operation Desert Storm may provide a general answer to this question.

What is not in question is the need for the commander to position himself on the battlefield so that he may influence, guide, and direct the action of his unit. Of sixteen armor battalion and cavalry squadron commanders interviewed after the fighting in Operation Desert Storm, all said that they positioned themselves within the unit so they could see the fight and control fires and maneuver. They also agreed that the commander should not focus his attention on acquiring targets or fighting one-on-one engagements. Many commanders felt that by fighting they lost their overall perspective of the battlefield situation, and thus their ability to command. The commander's best use of the tank's weapon systems was to give direction

or as an instrument of self-defense.[28] Thus, the armored task force commander must continuously focus on influencing the entire fight.

Determining the commander's position on the battlefield so that he may do this is more art than science. The commander moves to the critical point on the battlefield so that he may personally observe the terrain, the enemy actions and reactions, direct and indirect fires, and the situations of his own forces. He uses all his senses so that he may have a full understanding of the battlefield.[29] From this position he is able to determine the needs of his unit and request the necessary support. He intuitively operates from a position that allows him to comprehend the critically important information he needs for decision making. From this position he is able to make instant decisions and personally intervene in the operation only when needed.

The commander uses leadership to inspire his soldiers and encourage them to accomplish their mission. Moral and physical courage, will, audacity, and presence are leadership attributes of the exceptional tactical commander. They establish his moral presence on the battlefield. Soldiers who recognize these attributes in their commander feel the commander among them no matter what his location. Through leadership, the armored task force commander transforms the separate elements of his command into a body of energy prepared for action.

The armored task force commander's decisions direct his force into battle. The command decision is the most formidable and most critical of his battle command responsibilities. His decisions can be the result of a dynamic, yet very deliberate, process. The commander may also make a decision in a matter of seconds based on his intuitive judgment and a minimum number of facts. No matter which path the commander chooses, the decision is always a reflection of his will.[30]

Not all commanders are effective decision makers. Various commanders have different levels of cognitive tools that they apply in decision making. The two most prevalent characteristics of the commander's battle command decision making ability are *mental agility* and *judgment*.[31] The commander's mental agility reflects his creativity, an intuitive ability to quickly comprehend complex situations in the absence of certainty (*coup d'oeil*), a keen appreciation for the relevance of terrain, and the ability to anticipate. His judgment is predicated upon experience-based reasoning given certain critical information requirements. Each of these ingredients constitute a formula that enables the armored task force commander to comprehend the battlefield, decide quickly, and act without hesitation.

A key element of the commander's mental agility is his creativity. The command decision is in essence a creative act. The decision may contain many factors whose bearing and relevance are unclear. The armored commander often makes a decision with less than perfect information about the enemy. An unclear enemy situation affects the degree of specificity of the commander's mission.[32] The more unclear the enemy situation, the more general the terms that higher headquarters may use to state the task force's mission. In these circumstances, the commander must be innovative and insightful in his tactical decisions.

Insight is largely a measure of the commander's *coup d'oeil. Coup d'oeil* enables the commander to quickly and intuitively comprehend complex situations in the absence of certainty.[33] It is a product of natural talent, attitudes, and intellect honed by study of military theory. Combined with experience and analysis of the battlefield situation, *coup d'oeil* leads to sound decision making.[34]

The commander's sense for, and appreciation of, terrain is also a characteristic of his mental agility. The successful commander is able to

relate the terrain to appropriate tactics. Maurice de Saxe referred to this as *Fingerspitzengefuehl*, or one's instinctive sixth sense for terrain.[35] The commander must be able to see the terrain and the effects of weapons upon it in order to make sound tactical decisions. Israeli LTC Avigdor Kahalani's decision not to attack Syrian tank and infantry positions in the town of Mazrat Beit Jan during the 1973 Arab-Israeli War is an excellent example of an armor battalion commander's application of the correct tactic to the terrain, weather, and existing effects of weapons on the battlefield.[36]

Anticipation is also essential to the armored task force commander's mental agility. Commanders must read the battlefield in real-time if they are to have any chance of seizing the initiative.[37] This requires the ability to project and anticipate outcomes, much as LTC Kahalani did. Much of the art of command decision making is based on the commander's capacity to assess the outcome of his decisions before they are acted upon.

The art of command decision making is also a product of the commander's judgment. Judgment is the commander's ability to assess and integrate often questionable combat data with intuitive guesses in order to arrive at a decision that eventually proves to be correct.[38] Experience of the commander provides sound foundation for intuition. Data essential to the commander's decision making, his critical information requirements, supplies him with a cornerstone against which to apply his judgment.

Over time the successful armored task force commander builds a fairly comprehensive understanding of those tactical skills and information necessary for decision making in combat. This understanding enables the commander to separate essential information from the unimportant and to determine the veracity of the information.[39] The product of this ability is the recognition of the meaning and importance of certain events or key elements of information based upon his past training, study, or experience in combat

itself. The commander is then able to apply the meaning of the information to his command decision making process.

To do this, the commander must first have information. Having a great deal of information about the enemy forces, one's own forces, and geometry of the battlefield does not guarantee success in combat. The commander must have assessments with which to think and make decisions, not a surplus of unanalyzed information.[40] The staff and subordinate commanders must filter, analyze, and properly present information if it is to reduce the commander's uncertainty. The commander provides focus for them through his critical information requirements (CCIR). This enhances the timeliness of the information and allows the commander to more ably follow the flow of the tactical operation, thus enhancing his decision making ability.[41]

The armored task force commander's ability to make tactical decisions is largely a product of mental agility and judgment. Creativity, terrain appreciation, anticipation, and *coup d'oeil* are variables that signify the commander's degree of mental agility. Judgment is often a result of the commander's experience. Judgment enables the commander to make sound, quick decisions based on his critical information requirements.

Once the commander reaches a decision, he must ensure that the course of action unfolds as planned. He seeks confirmation that the unit is executing actions that will attain his tactical aim. This involves the science of battle command: *force control.*

In order to control the force, the commander must be aware of the unfolding tactical situation. His understanding of the tactical situation requires general knowledge of both friendly and enemy dispositions and actions, or *situational awareness*. Communication and navigation are essential to the commander's force control. Navigation allows him to

maintain spatial perspective on the battlefield. The commander provides direction and gains situational awareness through communication. Lastly, the commander must have computing power that can monitor and evaluate friendly force posture with respect to the tactical situation.

The armored task force commander constantly seeks to enhance his awareness of the tactical situation. He must know the exact location of his units as well as the status and positioning of adjacent, friendly forces.[42] Similarly, he must know the capability and organizational effectiveness of his subordinate units and the task force as a whole. He attempts to overlay the enemy situation with the friendly locations in order to complete his battlefield geometry. Situational awareness allows the commander to determine how well the force is executing the plan, what the enemy actions are, and if the plan requires any adjustments in order to achieve the commander's aim.[43] Enhancing situational awareness reduces the time needed to formulate a clear picture of battlefield. This will provide the commander more time to discuss the unfolding operation with staff and subordinate commanders.

In order to control the force, the armored task force commander must be able to communicate. The commander without effective communications risks losing control of the force and endangers the success of the mission. The communication system must be simple yet robust. It must allow him to communicate intent and orders vertically and horizontally within the organization.[44] Opportunities for face-to-face communication should not be overlooked, especially when the commander issues orders and intent. The commander's communication system enables him to retain his freedom of movement while still being able to influence the action from any point on the battlefield.

Movement on the battlefield requires the ability to navigate. The task force commander must know his location and the location of his forces in order to control them. The effectiveness of control measures in maneuvering the force is based on the ability of its soldiers to recognize their location in relation to the terrain. Efficient use of nonline-of-sight weapons, such as artillery and mortars, requires the maneuver force commander to accurately know the location of his forces on the battlefield. Navigation is key to situational awareness and thus plays a key part in reducing the risk of fratricide between and among forces.

Computing power is integral to force control.[45] As a decision maker, the commander must have a battle command support system that relieves him of the burden of information analysis. The commander's staff partially fills this role. The staff provides the commander with information, based on an analysis of available tactical data, that is useful for controlling the force. Automated battle command systems can also complement the staff's analysis, monitoring, and coordinating functions by providing the commander with certain physical tools that free him of manual situation display techniques.[46] Section III provides more information on a battle command system for the armored task force commander.

Battle command for the armored task force commander is a continuous process. Each of the elements link to, and therefore impact on, the others. Figure 2 illustrates the characteristics of each element of battle command as well as the characteristics that establish interdependence between the elements.

The commander is responsible for providing the force with a single unifying concept for his unit. His intent, or *vision*, is a function of the will of the commander to direct and motivate the force toward a common goal. The

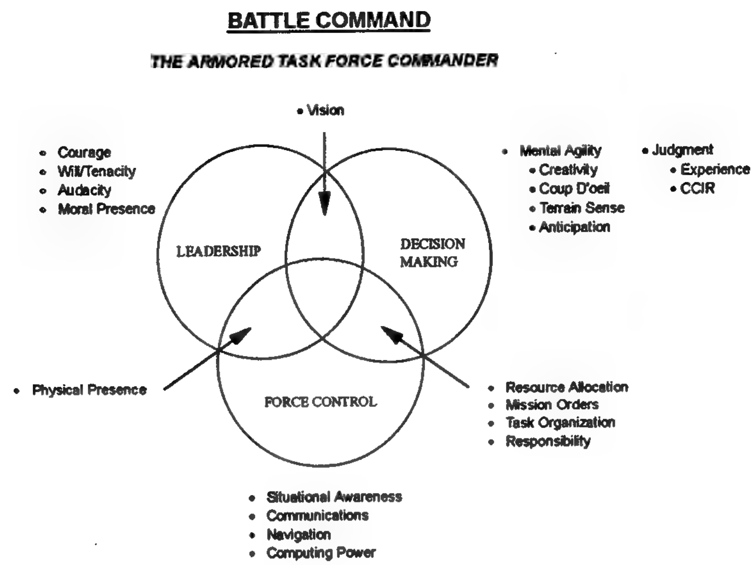


Figure 2. The Characteristics of Battle Command Elements

vision is not a decision on how best to accomplish the mission but rather the commander's articulation of what the force must accomplish and why. The commander's eventual decision on a course of action imparts his vision on the unit and serves as a focus toward preparation of ways and means for achieving the mission.[47]

Based on his vision, the commander applies mental agility and judgment in order to arrive at a decision. The creativity of the commander and his experience are key elements in the eventual decision. Upon reaching a decision, the commander develops a series of actions that his forces must accomplish. Mission orders and responsibility are assigned within the organization. The commander allocates resources to the force. He tailors the force and its battle command systems to ensure that his ability to control the force is timely and robust.[48]

The commander maintains situational awareness of the force, how effectively it is executing the mission, and any new resource requirements. He uses his communications system to assign or amend responsibility. The

computing power available to the commander determines new actions required of the force and further allocation of missions and resources.

The commander seeks a position on the battlefield from which he can control the force.[49] His physical presence allows him to view the fight and gain perspective on the array and status of both friendly and enemy forces. His presence far forward serves to inspire and direct forces and resources toward the achievement of his aim. From this position the commander can rapidly assess and influence the outcome of the battle.

The battle command requirements of the armored task force commander weave throughout the moral and cybernetic domains of battle. The commander leads the force morally and physically. He develops a vision for the force's success in combat and decides how the force will accomplish its mission. Lastly, he controls the force through will, mission orders, allocation of resources, communication, and maneuver. To do each, the commander must be able to operate far forward and do so effectively and efficiently. He currently does this from a tank. At first glance, the vehicle seems well suited to his requirements. However, before judging whether this fighting vehicle suits his battle command needs, it is necessary to have a glimpse of what the Future Main Battle Tank (FMBT) will look like.

III. THE FUTURE MAIN BATTLE TANK

Tank design is a highly complex art.[50]

The development and acquisition of a main battle tank is a complicated and costly business. It is a process that, depending on the acquisition strategy, can take as long as a decade. Definition of the requirements, or operational characteristics, of a new tank consumes much of the system's developmental timeline.[51]

Operational analysis of emerging technologies is often the foundation for selection and definition of a new tank's critical characteristics. These characteristics will most likely have a collateral impact on force structure and organization, operations and training, and most importantly, the potential threat. Doctrine will also impact on the characteristics of a new tank. Doctrine establishes how the future armor force will fight, and how its leaders will command, on the battlefield. The appropriate tank design characteristics with which to execute armor doctrine, including which characteristics to emphasize or de-emphasize, emanates from the experience-based imagination and vision of the combat developer.[52]

The U.S. Army's doctrine for the employment of the armored force on the future battlefield has significant impact on the design of its main battle tank. Army tank designers seek to achieve an optimal, cost effective balance between *lethality* (firepower), *survivability*, *mobility*, and *sustainability* in order to meet the doctrinal requirements. These are not the only characteristics of a tank though they are the most important.[53] The tank designer strives to establish an optimal balance among each without allowing any one characteristic to dominate the overall design.

The U.S. Army's Future Main Battle Tank (FMBT) is a perfect example of an effort to include emerging technologies in lethality, survivability, mobility, and sustainability into vehicle definition and design. Individual advancements in each of these areas will integrate with a highly sophisticated, yet flexible, electronics architecture in order to form a complete and synergistically enhanced fighting vehicle.

Lethality, or firepower, has always been near the top of the tank designer's priorities. The primary purpose for a tank is to deliver direct fire against an enemy at the required place and time.[54] To do so, the FMBT will have a mix of complementary weapon systems that range from the conventional tank cannon to more advanced and complex weapon systems, such as directed energy weapons (DEW).

The model FMBT for this study (pictured at Appendix A) uses a lengthened (55 calibers) 120 millimeter Advanced Tank Cannon System (ATACS) high pressure gun as the primary weapon system. The cannon mounts in a turret that also contains a 40-round, autoloading magazine. Storage space for an additional 23 rounds is in a reserve magazine at the rear of the tank's hull. Secondary weapon systems include a coaxially mounted, 30 millimeter cannon and 7.62 millimeter machine gun, an "off axis" hull machine gun, and a rearward firing 40 millimeter grenade launcher. Seven vertically launched anti-helicopter/anti-air missiles are mounted at the rear of the turret.[55] A low energy laser may serve as a directed energy weapon (DEW) capable of temporarily incapacitating enemy soldiers or disrupting enemy vehicle optical sighting systems.[56] The DEW complements the offensively related ATACS, 30 millimeter cannon, and machine guns by providing a defensively oriented weapon that can engage enemy weapon systems and render them ineffective until the tank's main armament can engage or until the tank moves to a protected position.

The history of warfare is replete with examples of the desire to gain advantage through weapons while also seeking protection against them. The FMBT is such as example. Survivability of the vehicle and its crew is a key characteristic of the FMBT design and is a product of the tank's passive and active protective systems.

Passive survivability systems on the FMBT include armor plating made from advanced materials and material processing. High strength composite armor, advanced polymers and elastomers, and ductile ceramics provide increased ballistic protection for the FMBT's crew. Many of these materials are lighter than conventional and reactive armor, and thus significantly enhance the FMBT's maneuverability and speed.[57]

Placement of the FMBT's powerpack (engine and transmission) in the front of the tank, forward of the crew compartment, also increases crew protection. Forward placement of the powerpack increases the path length that an armor piercing projectile must travel in order to penetrate the crew compartment.[58] A forward-placed powerpack also allows the crew access to the rear of the tank without having to exit the vehicle from the top of the hull. A crew compartment door at the rear of the tank is especially useful when the tank is in a defensive position and the crew wishes to leave the vehicle without exposing themselves to enemy fire. They may also evacuate a wounded crew member while using the front of the vehicle for protection.

Another factor of the FMBT's survivability is its low profile.[59] Decreasing the tank's silhouette makes the vehicle more difficult to acquire and hit. Placing the tank's three-man crew in the vehicle hull reduces the requirement for space and armor protection in and around the turret. Thus, the smaller, unmanned turret not only reduces the height of the tank, but also its weight.

The use of low observable technology will also lessen the FMBT's silhouette. Low observable technology reduces the signature of the tank below the detection threshold of enemy thermal and acoustic sensor systems. Contouring armor on the tank and using radar absorbing material minimizes the radar cross section of the vehicle and makes it potentially undetectable.[60] Increased effectiveness of these types of survivability techniques also decreases the need for heavier, passive armor.

Increasing numbers of anti-armor weapons and munitions mandate the integration of a protective suite of active survivability systems on the tank. A comprehensive fire suppression and life support system and built-in nuclear, biological, and chemical (NBC) defense equipment, enhance crew survivability.

Radar and laser receivers provide warning against these types of sensor systems and will also locate and classify threats using preprogrammed laser-pulse identification codes and computer-processed vehicle signature algorithms.[61] The tank is also equipped with an "anti-mine micro-wave grill" capable of projecting a magnetic "image" of the tank some distance forward of the actual vehicle.[62] This provides active protection against magnetic anti-tank mines.

A Vehicle Integrated Defense System (VIDS) will serve as a link between the active, warning systems on the tank and a suite of complementary countermeasure systems. The VIDS uses microelectronics and computer processing to synergistically combine all the capabilities of each threat detection system into capstone warning system. It also acts as a conduit into a number of onboard countermeasure systems. The VIDS will automatically initiate appropriate countermeasure responses such as multispectral smoke grenades and chaff as well as provide the crew with automatic weapon aiming against identified threats.[63] The VIDS will assist in

decreasing the crew's reaction and decision making time on an increasingly dangerous and complex battlefield.

The mobility of the FMBT will serve a dual purpose. First, the FMBT's mobility will allow the tank to move quickly on the battlefield to apply its firepower at the critical time and place. Second, mobility (speed and movement capability) also complements crew survivability by reducing the potential for the vehicle to be hit by an enemy.[64] Advanced propulsion technologies are expected to enhance the FMBT's mobility by boosting efficiencies in power-to-weight and power-to-volume ratio and thus increase vehicle speed and range.

The FMBT will use an Advanced Integrated Propulsion System (AIPS) that will continue to deliver power equal to that of the M1A1 tank's powerpack while reducing the size of the powerpack by 50 percent. This reduction provides 3.5 cubic meters of space that can be used for additional crew space, ammunition storage, or to reduce vehicle size.[65] The use of electric drive motors, composite materials for the engine, active suspension, and advanced engine combustion, cooling, and heat rejection will create dramatic payoffs in the FMBT's range, mobility, design flexibility, burst power, and vehicle stability.[66]

The FMBT will incorporate several features that enhance the sustainability of the tank. Built-in test systems will provide automated diagnostics and prognostics of the tank's major components (powerpack, batteries, VIDS, fire control, etc.,) and the entire electronics architecture. The FMBT's Vehicle Control and Operating System (VCOS) will be capable of automatically correcting subsystems, such as engine operating parameters in order to enhance fuel efficiency, that are out of tolerance and operating at less than optimal levels.[67] Built-in test systems will also reduce the time

required by the crew to conduct preventive maintenance checks. Thus, the crew gains additional time for mission preparation and crew rest.

The VCOS will also allow the crew to make adjustments to operating systems from within the crew compartment. For example, the vehicle commander could determine what track tension setting is appropriate for the type of terrain over which the tank is traveling. He provides this information to the VCOS which, in turn, electronically sets the tensioning idler on the track to the correct setting. The VCOS will also provide the crew with embedded technical manuals and an automated maintenance "help" reference system similar to most conventional computer programs. This will reduce maintenance and repair times. The VCOS computer database will also maintain a historical status of all FMBT major components and provide each tank with its own distinctive, on-board "automated equipment logbook."[68]

Reducing the tank crew's physical burden is also a measure of the overall sustainability of the FMBT. The FMBT will have an autoloading system for the main cannon; thus, the tank only requires a three-man crew. Resupplying tank main gun ammunition is accomplished from the rear of the vehicle through an automated, mechanical loading sequence between a rearming vehicle and the tank. Manual crew interaction will not be necessary. The sustainability features of the tank not only help to maintain its operational performance, but that of the crew's as well.

The brain and nervous system of the FMBT will be its Vehicle Control and Operating System. The VCOS is an automated computer system that can transfer, store, integrate, and present information within the vehicle or to other similarly equipped vehicles. The crew will use the VCOS to functionally control and operate the FMBT. The VCOS will assist the crew by automatically regulating system power distribution, controlling

automotive subsystems, and exchanging information among the vehicle's lethality, survivability, mobility, and sustainability subsystems.[69]

The crew will control the lethality and survivability subsystems of the FMBT from their respective fighting stations. Using artificial intelligence, the VCOS will support the crew by providing recommended responses to enemy threats or by automatically engaging enemy targets. The VIDS sensors will provide enemy target information that the VCOS then uses to compute fire control solutions, select the appropriate weapon system, and engage the target. The crew may override the system at any time. The VCOS can automatically employ VIDS countermeasures against detected threat weapon systems, or will enable the crew to manually employ a different countermeasure.[70]

The VCOS will control all sustainability functions of the FMBT. The mission support and sustainment elements of the VCOS will include FMBT system diagnostics and prognostics, automated technical and maintenance manuals, and embedded training for the crew. The VCOS computer database will store all historical information about the operating condition and maintenance of the FMBT's subsystems. The VCOS will also monitor and regulate crew compartment and vehicle environmental control systems for both normal and emergency operations.[71]

The last functional element of the VCOS is Command, Control, Communications, and Intelligence (C3I) operations. The VCOS C3I support system will control the FMBT's battle command software applications.[72] The FMBT will have a "battle command system" that will assist in vehicle positioning and navigation. It will also enable the exchange of critical tactical information among vehicles on the battlefield. Lastly, it will display tactical information on the vehicle commander's display in a form that best suits his needs.[73]

The FMBT's battle command system will be similar to the Combat Vehicle Command and Control (CVC2) System, the second generation of the Intervehicular Information System (IVIS) currently on the U.S. Army's M1A2 tank. Like the CVC2 system, the FMBT battle command system will provide a tactical display containing friendly operational maneuver graphics, the real-time position locations of friendly vehicles or units, information about the enemy, and digitally displayed map data.[74] The system will enable the vehicle commander to rapidly develop and transmit, or receive, tactical situation reports to or from higher headquarters. The ability to digitally transmit tactical graphics, reports, and logistics data using vehicle communications systems will establish a level of vertical and horizontal information integration among battlefield commanders never realized before. The enhanced battle command network will aid in solving "many of our most pressing battlefield shortcomings, such as fratricide, situational awareness, and dissemination of information, to include overlays, in a timely manner."[75]

The vehicle commander, by virtue of his experience and rank, will most likely operate the FMBT's battle command system. Using his tactical display, he will be able to monitor the location and progress of many of the combat vehicles that he cannot see visually because of terrain masking, battlefield obscuration, or limited visibility. At the lowest tactical levels, the FMBT commander will typically develop and transmit most of the digitally formatted tactical situation reports. The reports will: contain information on the friendly and enemy situations, and friendly logistical status; enable the FMBT commander to request indirect fires; and provide information on battlefield geometry.[76]

The FMBT's battle command system will assist in speeding the plans-orders cycle through rapid exchange of orders and overlays, will

increase the tank commander's situational awareness, and will allow the unit commander to better synchronize the movement of his force and its fires. The ability to navigate with near certainty of own vehicle and unit locations will facilitate rapid massing of forces and fires, while ensuring force survivability through better tactical dispersion.[77] The FMBT's battle command system will furnish the commander at battalion level and below with the tools he needs to maintain control of his forces on an ever increasing and more complex battlefield.[78]

The FMBT's VCOS will function through a vehicle electronics (Vetronics) architecture similar to the avionics in the current generation of tactical aircraft, such as the U.S. Air Force's F-16 and the Navy's F/A-18.[79] The standardization of computer and electronic components and subsystem interfaces, power distribution, and information transfer within a vehicle form the basis for the concept of Vetronics .

Under the Standard Army Vetronics Architecture (SAVA), the FMBT will share many of the following common, interoperable and interchangeable components with other vehicles within the Army's future vehicle fleet: power supplies, data and power buses, displays, standardized driver and vehicle commander compartments, position and navigation equipment, automotive and mobility systems, and electrical and electronic systems and interfaces.[80] Thus, the SAVA will provide the future armored family of vehicles with commonality and standardization that is nonexistent in today's fleet. The SAVA will reduce production, operations, and sustainment costs while providing combat vehicle designers with a degree of flexibility to rapidly reconfigure the interior of combat vehicles based on new requirements.[81]

There is no question that the FMBT will have many of the characteristics to make it one of the premier tanks on the battlefield in the

early 21st century. Its superior lethality, survivability, mobility, and sustainability will ensure this. Additionally, its state-of-the-art electronics architecture will provide a weapons system with significant growth potential in each of these design areas. The FMBT's battle command system will certainly provide a quantum leap in the ability of the tactical commander to better understand and control the battlefield situation. The battle command system satisfies many of the armored task force commander's battle command force control requirements. Given its currently defined characteristics, however, it is uncertain whether the FMBT will meet the commander's leadership and decision making requirements.

IV. ANALYSIS: THE NEED FOR A COMMANDER'S FMBT

> The essential message is that, while the latest Army doctrine calls for the commander to operate on his tank in a certain fashion, the equipment provided for him to do this is less than satisfactory.[82]

The intended tactical role of a combat vehicle is perhaps the most important aspect that designers must consider when configuring the vehicle's fighting compartment. Whatever the tactical role of the vehicle, the vehicle commander must be able to execute his battle command responsibilities from within the vehicle. This is a fundamental principle of tank design that is relevant for every vehicle commander, but is especially critical for commanders of tactical units.[83] This principle is no less true of the FMBT and the armored task force commander. He must be capable of performing his battle command leadership, decision making, and force control functions while operating from the FMBT. Any degradation in his ability to do these requires reevaluation of the FMBT's crew compartment layout. Analysis of the FMBT's *versatility, flexibility, and fightability* illuminates the need to develop a FMBT designed specifically around the armored task force commander's battle command requirements.

Versatility is the only quality of the FMBT that sufficiently meets the armored task force commander's battle command needs. The commander requires a combat vehicle capable of being multifunctional; it must provide him with mobility, survivability, and a limited degree of lethality.

The FMBT provides the commander with mobility equal to that of his combat force. By operating from a FMBT, the commander is in a vehicle with the same speed, maneuverability, and range as his combat elements. The commander is able to lead from the front, position himself at the critical

place on the battlefield, and maintain pace with the elements he must control.

Operating from a FMBT, the commander achieves the survivability he needs to command forward. The passive and active protection of the FMBT gives the commander the latitude to position forward with his units to see the battlefield and provide inspiration to his subordinates. Additionally, in contrast to a Command Group Vehicle of distinct design, the reduced vehicle signature of the FMBT provides the commander with another crucial element of his survivability.[84] The commander's FMBT will blend with the unit tactical formation and make it impossible for enemy gunners to identify the vehicle as a high payoff target. Survivability through reduced signature and enhanced protective systems equal to the rest of his force allows the commander to focus on his battle command tasks and devote less effort to defending his combat vehicle in its forward location.[85]

To be survivable, the commander's FMBT must have sufficient armament for self-defense.[86] The combination of the FMBT's directed enegery weapon (DEW) and its VIDS countermeasures provide satisfactory survivability systems for the commander. These technological innovations are an adequate substitute for the tank's main cannon as a means for vehicle defense. Eliminating the need for the main gun as a defensive weapon, however, does not diminish its importance as a key element in FMBT signature reduction. For this reason, the tank main gun must remain on the commander's FMBT, or at least a mock version of the cannon. The removal of the main cannon's breech, autoloader, ammunition carousel, and hull ammunition storage space requirement provides the tank designer with a significant and much needed space gain.

The additional space realized by mounting a mock main cannon is critical to the flexability of the commander's FMBT. The commander

requires a vehicle that allows him to exercise his personal method of battle command. To facilitate decision making, he must be able to organize his staff according to his own way of command.[87] The FMBT with its limited crew space and three-man crew prohibits any such flexibility. Should the commander desire to have a key member of his staff onboard his FMBT, he would have to replace either his driver or gunner/assistant tank commander. Replacing one of his crewmen would require the commander to assume the vehicle control and operation duties of the gunner/assistant tank commander. Assuming this role would increase the commander's responsibilities and actions as a member of the tank crew while degrading his ability to command the unit.

Two aspects of the commander's ability to execute battle command would improve by having the flexibility to include key members of the staff on a Commander's FMBT. First, he would be able to conduct face-to-face exchange with select members of the staff. Face-to-face exchange of information is an extremely useful and timely technique when attempting to build a mutual image of the battlefield situation and would significantly facilitate decision making. Personal, interactive contact between the commander and key staff is superior to the traditional linear information flow in which the staff provides the commander information and he, subsequently, provides them with a decision. Face-to-face exchange of information, assessments, and intent is a critical supplement to information disseminated by technology, such as the graphics and messages through the FMBT's VCOS C3I battle command system, and is an essential part of the command process.[88]

Furthermore, face-to-face discussion between the commander and other members of his command group would decrease the number of voice radio transmissions on key nets. Reducing the number of transmissions on

the commander's key radio nets would make the nets less susceptible to enemy communications jamming and intercept. Face-to-face exchange of information between the commander and a supporting staff will also enhance his feeling of having adequate information for decision making. The confidence inspired by having more immediate access to analyzed information should relieve the commander of the temptation to direct the battle from a Command Post Vehicle.

Second, the ability to have select staff members on the commander's FMBT provides them with the same degree of survivability as the commander. No longer would the commander's Air Liaison Officer and Fire Support Officer have to operate from a significantly more vulnerable vehicle. A commander's FMBT that serves as a Command Group Vehicle (CGV) might also reduce the requirement for a second and more survivable vehicle assigned to each member of the command group. Reducing the number of vehicles with distinct signatures in the armored task force commander's command group should increase the survivability of the command group as a whole.

The ability to position key staff farther forward with the commander, and thus benefit from the same battlefield picture as he, also enhances the Tactical Operations Center (TOC) staff's understanding of the tactical situation. Operating at the same location on the battlefield as the commander would allow a forward staff to relay what they see, hear, and feel back to their counterparts at the TOC. Immediate and enhanced communication with a forward counterpart should improve the TOC staff member's image of the battlefield situation by allowing them to exchange information pertinent to their respective staff function. Communication between a forward staff and the TOC will also reduce the burden on the commander to provide the image of the tactical situation to the TOC.

How many members of the staff should the commander include on his FMBT? The number of supporting staff members depends on the commander's personal needs and specific mission requirements. An assessment of the commander's requirements prior to any actual research effort by tank developers indicates that the Commander's FMBT should have between five to seven personnel, including the driver, gunner, and tactical commander. The commander could have up to four staff members, or "crew station operators" who could provide him with information he requires for decision making.[89] Any of the personnel could perform force control functions for the commander, such as developing fragmentary orders, concept sketches, or text messages to higher headquarters.

In either instance, the result is the reduced workload and functional detachment of the commander from the battle command system's tools and applications. This detachment is key to improving the commander's decision making, for it provides him added opportunity to think and contemplate the meaning of what he sees, hears, and feels of the battlefield and what his staff tells him on the radio or face-to-face from within the vehicle.[90] He may have a tactical display, but it would merely supplement his own view of the battlefield and what information he receives orally from the staff.

The fightability of a Commander's FMBT is complicated by the degree of flexibility the commander desires. Fightability is nothing more than the ability of humans to operate within the FMBT and perform their designated crew or staff support functions. Fightability is characterized by the space, the man-machine interface tools, and the adaptability of the support system on the vehicle to perform these functions.[91]

As previously mentioned, significant space gain on the FMBT is possible with the removal of all systems related to the main cannon from the turret interior and the hull. Removing these systems leaves the space below

the turret ring and at the rear of the hull (previously the location of the hull ammunition storage compartment) for the four workstations of the staff or crew station operators. Less protected space in the turret above hull level could be reserved for additional vetronics hardware and the DEW's fire control system. Therefore, vehicle space for a larger crew should not be an insurmountable problem in the development of a Commander's FMBT.

The SAVA will provide the staff and crew station operators with tactical displays and communications to perform their respective battle command support functions. Vehicle intercommunication among the staff, commander, and crew will exist through the SAVA. Software applications for each staff officer to perform their staff function would reside on the VCOS.[92] The staff officer need only "log-in" to the system, and he will have the tools he needs to support the commander for decision making and situational awareness. Enabling the staff on the commander's FMBT to have full access to their respective support systems allows the commander to conduct planning with key members of his staff as the tactical situation shifts and the need to redirect the force increases.

The SAVA will also provide an adaptable design framework for the tank designer as battle command requirements change. This open-ended architecture has significant room for growth, particularly in data distribution and control, computer resources, and interfaces among multifunctional crew controls and displays.[93]

The degree of deviation from the design of the model FMBT presented in Section III merits a hard look at the feasibility and acceptabilility of this tank as a command platform for the armored task force commander. Significant, yet realizable, modifications can be made to the FMBT to accommodate the commander's battle command requirements.

While the model FMBT is versatile in its ability to support the commander's requirements for mobility and survivability, a tradeoff is possible in lethality based on the commander's primary role as a leader and decision maker. Limitations on the commander's flexibility to organize his command group as he sees fit can be overcome through modification of the FMBT's turret and hull interior. The SAVA and VCOS of the future FMBT provide respective architecture and battle command system applications around which tank designers can build a Commander's FMBT. As it currently exists in requirements and concepts, the FMBT provides an adequate shell from which the commander may conduct battle command. Modifications to the FMBT are possible and should be strongly considered based on the armored task force commander's battle command requirements.

V. CONCLUSIONS

> We must conclude that there is still much to be done if we are to meet the requirements of warfare in this decade. The U.S. Army has not yet accomplished its mission in this most critical area of C^2. We must take steps to remedy this situation. As an institution, we owe our best efforts to those who command and those who fight-*on the move!*[94]

The intent of this paper is not to refute the tank as a worthy command and control vehicle for the armored task force commander. On the contrary, the tank provides the commander with much needed mobility and survivability. What is evident, however, is the need for a FMBT that gives the commander a degree of flexibility, enabling him to exercise his own personal style of battle command.

The FMBT must support the commander's leadership, decision making, and force control battle command requirements. He must be capable of moving about the battlefield with the same freedom as his unit. He should be able to organize his staff for effective and timely decision making. Lastly, the commander must be able to redirect the force when necessary.

The designers of the model FMBT used in this paper were not required to develop a multifunctional tank. The limited definition and detail of the model, however, does not dismiss the *need* for a multifunctional FMBT. The Germans recognized this very point just prior to World War II. Despite this historical precedent, a review of the FMBT's draft requirements documents leads one to conclude that little thought has been given to the need for a multifunctional tank within the armor battalion.[95]

The lack of literature or research and development that might otherwise indicate the Army's desire for a multifunctional tank is puzzling for

two reasons. First, there have been explicit attempts by the Army to modify contemporary combat vehicles so that the commander could have a supporting staff member operate with him face-to-face.[96] While the technology to modify these vehicles permanently would not support the operational concept, the FMBT requirements reveal nothing other than a three-man combat vehicle. Second, the flexibility of the SAVA should encourage tank designers to continue the work of these earlier efforts. Modifications to the basic design of the FMBT will be significantly easier with the SAVA. Some tradeoffs might have to be made, such as lethality, when creating a vision for the commander's FMBT. Given the direction of our technology initiatives for lethality systems that the commander may need,[97] the choice of a weapon for self-defense should prove to be little more than a speed bump in the development of requirements for a Commander's FMBT.

At first glance it would appear that producing a multifunctional FMBT would be difficult and costly. However, the assembly of at least two versions of the FMBT on the same production line should pose no barrier to a Commander's FMBT. The common crew station components realized through SAVA will complement the "flexible tooling" of the future assembly line. Thus, both a Commander's FMBT and a standard FMBT can be produced on the same assembly line so long as the hull designs are similar.[98] Producing a Commander's FMBT, a relatively small number of tanks within the total fleet, should not be cost prohibitive when using SAVA's common components and the same assembly line.

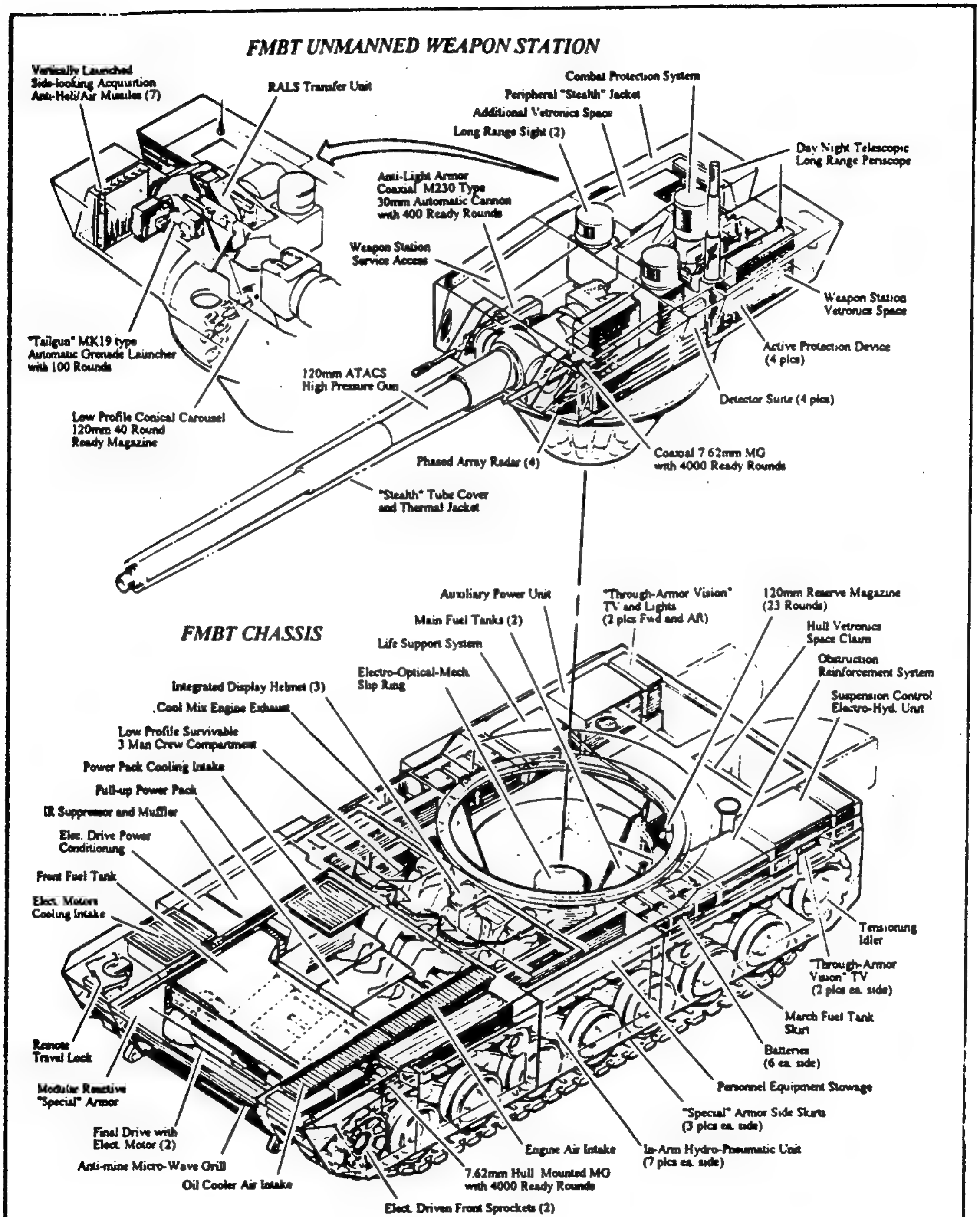
As the quotation at the beginning of this section states, there is still much to be done in developing the requirements for a Commander's FMBT. Fortunately, there are several research and development tools available to the tank designer as he tackles this formidable task.

The battle command requirements presented in Section II of this paper lay the doctrinal groundwork for further investigation of the commander's leadership, decision making, and force control needs. Using these basic principles as a guide, combat developers can determine how emerging technologies for the FMBT can best support the commander as he executes battle command. The SIMNET-CD system at Fort Knox appears to be the mechanism that can best integrate field soldiers with these technologies. This system networks groups of reconfigurable, high-fidelity tank crew simulators in a simulation environment that includes visual, auditory, and tactical stimuli.[99] The SIMNET-CD system would allow the combat developer to observe the commander's FMBT staff, system operators, and crew members as they interact with emerging battle command systems technologies during various tactical situations. It can also collect research information on the tactical effectiveness of the commander's FMBT to support his decision making and situational awareness in a wide range of simulator configurations. Both the Directorate of Combat Developments and the Mounted Warfighting Battlespace Laboratory at the U.S. Army Armor Center should embark on a study that will refine the operational concept for a Commander's FMBT. This study might include, as a minimum, the onboard interaction among the staff and the commander and the expanded or contracted role of the Tactical Operations Center. The operational concept could then be used as a basis for operational requirements as well as the eventual development of tactics, techniques, and procedures.

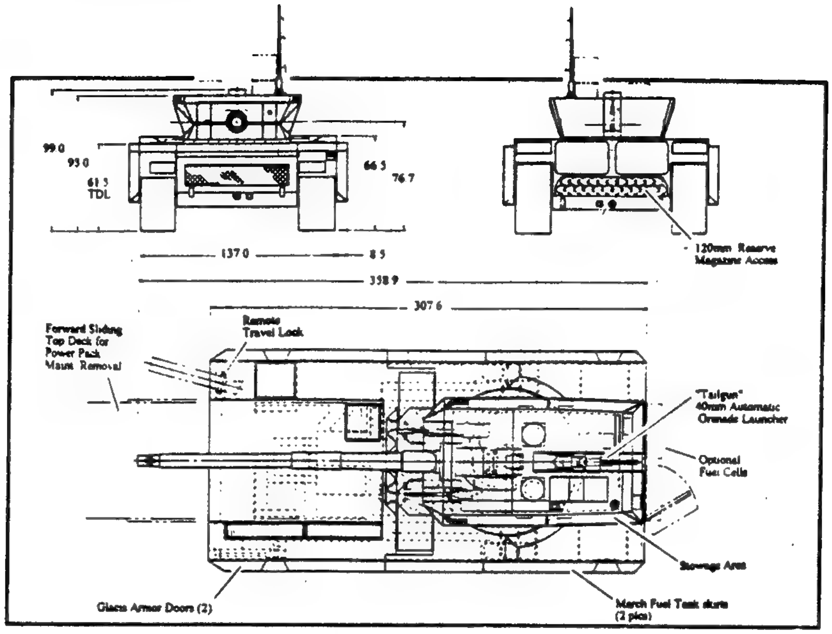
The second area requiring analysis by tank designers is the configuration of the crew compartment for the Commander's FMBT. The Vehicle Crew Display Demonstrator (VCDD), developed under the Army's Vetronics program, is the best instrument for evaluating crew station

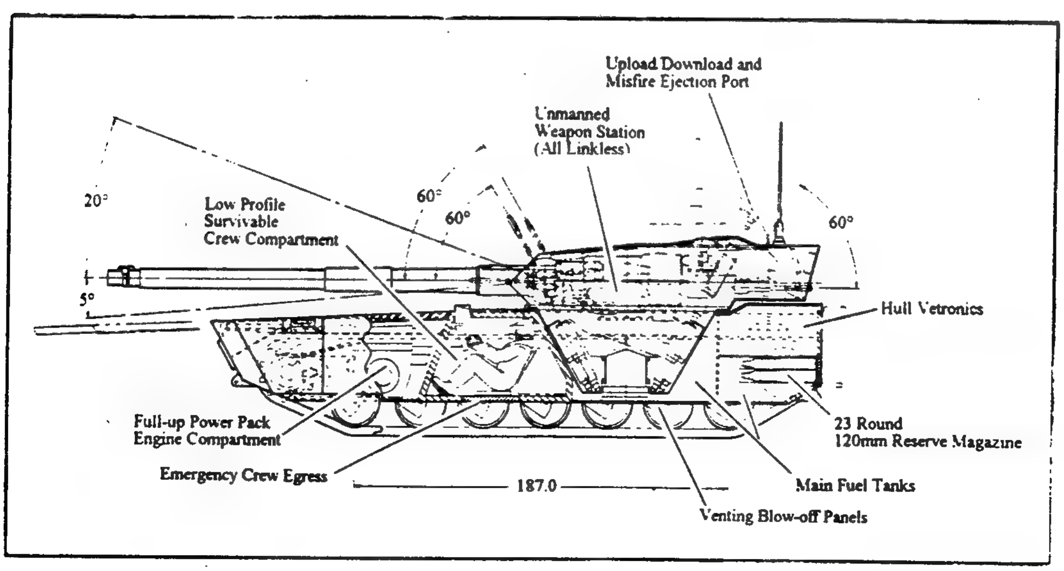
configurations for combat vehicles.[100] As the VCDD is primarily for single-crew operation, the research effort should concentrate on human factors analyses and display interfaces for various crew members. This effort will provide the combat developer with operational requirements for map displays and graphics, text messages, man-machine interface tools, and optical sighting. The VCDD research should be complementary to the SIMNET-CD effort, each feeding the other with lessons learned. The result of these efforts is the definition of a vehicle that will suit the armored task force commander's needs for combat in the 21st century.

Appendix A: Model Future Main Battle Tank[101]



Appendix A: Model Future Main Battle Tank





ENDNOTES

[1] Richard E. Simpkin, Human Factors in Mechanized Warfare (New York, NY: Brassey's, 1983), p. 47.

[2] LTC John W. Mountcastle, U.S. Army, "On the Move: Command and Control of Armor Units in Combat," Military Review (November, 1985), pp. 17-18.

[3] Ibid., p. 23.

[4] Ibid., pp. 36-37.

[5] Review of the Command and Control Vehicle Operations Concept (Combined Arms Command, Combat Developments, draft, 5 May 1993), the Capstone Armored Systems Modernization Required Operational Capabilities (ASM ROC) (including the Command Group Vehicle), and Armor Center presentations on the Brigade Commander's Battle Command Vehicle provide the evidence for this analysis. The ASM CGV is intended to be on a medium chassis variant of the common chassis and have a signature similar to the Future Infantry Fighting Vehicle. The Future Main Battle Tank will use a heavy version of the common chassis. As Mr. Murray Hammick states in his article "The Armored Systems Modernization Program" in International Defense Review (September, 1991), p. 970, the design and appearance of these two vehicles could be driven apart by dissimilar protection requirements and future technical innovations. The vehicle envisioned in the Combined Arms Command and Armor Center programs is a Bradley/MLRS chassis mounting a shelter for the command group. The vehicle signature is distinctive, and survivability to direct and indirect fires is low.

[6] Eric C. Ludvigsen, "Armor's Future: From One, Many," Army (May, 1991), p. 33.

[7] John G. Ross, "Seven Years After M-1 Fielding, Army Still Can't Yank Tanks," Armed Forces Journal International (October, 1989), pp. 90-92. Mr. Ross reviews several aborted attempts in the late 1980s to fund and field a replacement for the M88A1 Armored Recovery Vehicle. Another excellent reference that addresses this problem is the U.S. Army Armor Center 1984 Armor Conference White Paper, "Combat Service Support - At War." Unfortunately, several of the service support systems that the paper recommends for replacement or upgrade are still in the fleet 10 years later, with no immediate replacements or modifications in sight.

[8] Bryan Perrett, The Panzerkampfwagen III (London, England: Osprey Publishing, 1980), pp. 10-11.

9 Jane's Armour and Artillery 1992-1993, 17th edition, ed. Christopher F. Foss (Surrey, England: Jane's Information Group, 1992), p. 79.

10 This assessment is based on review of the U.S. Army Armor and Engineer Board Command and Control Vehicle Concept Evaluation Program (CEP) done in conjunction with the Armor School's Directorate of Combat Developments. The modifications included: an additional two radios, Digital Message Device (DMD) mounted just inside the loader's hatch, steel map tables welded to the top of the turret at the loader and tank commander's positions, steel binocular cases welded to the turret exterior, two additional antennas, and a multiplexer. The general concept is based primarily on enabling the task force Fire Support Officer to operate from the loader's hatch of the task force commander's tank. Several problems were created in the vehicle communications system as a result of the additional radios and the DMD. The M1 version had radios mounted in the ammunition stowage area just behind the tank commander. This violated the integrity of the crew compartment's survivability enhancements by requiring that the turret ammunition compartment blast doors remain open so that the radios would not overheat. A minor issue was the ability of the Fire Support Officer to perform the duties of the loader (man a 7.62mm machinegun, load the main gun, etc.,) if required.

11 Rick Megahan, "Battalion Command in Combat - Forward Edge of Combat Power: A Leadership Analysis of Selected Battalion Commanders in Combat in World War II, Korea and Vietnam With Implications for Future Combat Leaders" (U.S. Army Command and General Staff College, Master of Military Arts and Sciences Thesis, 1990), p. 1.

12 U.S. Army, Field Manual 100-5, Operations (Washington, DC: Department of the Army, June 1993), pp. 2-14 to 2-15.

13 Ibid., p. 2-15.

14 Mountcastle, p. 38.

15 FM 100-5, pp. 2-14 and 2-15. FM 100-5 states that "command has two vital components -- decision making and leadership." Leadership is "inspiring and directing assigned forces and resources toward a purposeful end." Control is "inherent in battle command," yet is seen as more a function of the staff than the commander. The staff works "within command intent to direct and control units and resource allocations to support the desired end." Control, however, must allow "the commander freedom to operate, delegate authority, lead from any critical point on the battlefield, and synchronize actions across his entire AO."

[16] Norman L. Grunstad, "The Total Army Leadership Goal: Where We Are," in Leadership on the Future Battlefield, ed. James G. Hunt and John D. Blair (Washington, DC: Pergamon-Brassey's, 1985), p. 234.

[17] U.S. Army, Combined Arms Command, Draft "Battle Command Concept" (Fort Leavenworth, KS: U.S. Army Battle Command Battle Laboratory, no date), p. 3.

[18] U.S. Army, Field Manual 71-2, The Tank and Mechanized Infantry Battalion Task Force, (Washington, DC: Department of the Army, September 1988), p. 2-2.

[19] Brigadier General Huba Wass de Czege, U.S. Army, "A Comprehensive View of Leadership," Military Review (August, 1992), p. 21.

[20] Anthony Kellett, Combat Motivation: The Behavior of Soldiers in Battle (Boston, MA: Kluwer, 1982), p. 159. Kellett states that U.S. studies of command leadership in the early 1960s revealed that forcefulness, personal resourcefulness, and persistence were key elements in the projection of leadership. According to Kellet, successful combat leaders provide unambiguous directions, are concerned for the welfare of their men, and serve as a good example for their soldiers to emulate. These characteristics are similar to the FM 100-5 description of leadership on page 2-15. Additionally, in Leadership in Combat: An Historical Appraisal (West Point, NY: West Point Press, 1984), LTC Kenneth E. Hamburger's study of over 200 successful combat leaders resulted in five characteristics present in each: physical courage, tenacity, audacity, terrain sense, and judgment. The latter two characteristics will fall under decision making in the battle command model.

[21] James L. Stokesbury, "Leadership as an Art," Robert L. Taylor and William E. Rosenbach, eds., Military Leadership: In Pursuit of Excellence (Boulder, CO: Westview Press, 1984), p. 17.

[22] Major Geoffrey G. Prosch, U.S. Army, "Israeli Defense of the Golan: An Interview with Brigadier General Avigdor Kahalani, Israeli Defense Forces," Military Review (October, 1979), pp. 9-10. BG Kahalani's battle tested opinions are seconded in the Training and Doctrine Command (TRADOC) Pamphlet 525-100-2, Leadership and Command on the Battlefield--Battalion and Company. Based on interviews with 16 armor battalion or cavalry squadron commanders, the pamphlet states that "all commanders commented that their presence and visibility forward on the battlefield were important. Many asserted that their presence ... increased the confidence and morale of the soldiers. Many believed it important for their soldiers to know that their commander led from the front and therefore shared their

hardships and the rigors and danger of combat. The commander's forward presence is necessary not only to allow the commander to view the battlefield, but also to allow the men to see the commander." (p. 29).

[23] Lothar Rendulic, "The Command Decision," in Course 1 Readings: Foundations of Military Theory (Fort Leavenworth, KS: U.S. Army Command and General Staff College, School of Advanced Military Studies, no date), pp. 30-31.

[24] Ibid., p. 29.

[25] Colonel S.L.A. Marshall, AUS, Men Against Fire: The Problem of Battle Command in Future War (Gloucester, MA: 1978), p. 105.

[26] Lewis Sorley, "Creighton Abrams and Levels of Leadership," Military Review (August, 1992), pp. 7-8.

[27] Draft "Battle Command Concept," pp. 7-8.

[28] U.S. Army, Training and Doctrine Command (TRADOC), TRADOC Pamphlet 525-100-2, Leadership and Command on the Battlefield: Battalion and Company (Fort Monroe, VA: U.S. Army Training and Doctrine Command, 1993), pp. 23-24.

[29] General Matthew B. Ridgway, U.S. Army, "Leadership," in Taylor and Rosenbach, p. 29.

[30] Rendulic, p. 19.

[31] Hamburger, pp. 1, 8.

[32] Rendulic, pp. 34-35.

[33] Carl von Clausewitz, On War, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), p. 102.

[34] Donald D. Chipman, "Clausewitz and the Concept of Command Leadership," Military Review (August, 1987), p. 36.

[35] Major Peter J. Palmer, "Developing Tactical Commanders at CGSOC for the Future Air Land Battlefield" (Fort Leavenworth, KS: U.S. Army Command and General Staff College, School of Advanced Military Studies Monograph, 1990), p. 13.

[36] Brigadier General Avigdor Kahalani, IDF, The Heights of Courage: A Tank Leader's War on the Golan (New York, NY: Praeger, 1992), p. 153. In this situation LTC Kahalani decided not to attack a fortified Syrian position located in the town of Mazrat Beit Jan. From his forward position, he could not see all the Syrian tanks and infantry trench lines due to battlefield obscuration and the Syrian's excellent use of concealment. He notes that the advantage of attacking with the sun at his back will most likely not offset the Syrian defensive advantage.

[37] Lieutenant General Leonard P. Wishart, U.S. Army, "Leader Development and C2," Military Review (July, 1990), p. 13. Of interest also is S.L.A. Marshall's approximation that the art of command is 60 per cent anticipation, 40 per cent improvisation. See Men Against Fire, p. 108.

[38] John W. Gardner, On Leadership (New York, NY: Free Press, 1990), p. 49.

[39] Hamburger, p. 2.

[40] Theodore Roszak, The Cult of Information: The Folklore of Computers and the True Art of Thinking (New York, NY: Pantheon Books, 1986), p. 88.

[41] Draft "Battle Command Concept," p. 19.

[42] TRADOC Pamphlet 525-100-2, p. xi.

[43] Draft "Battle Command Concept," p. 17.

[44] Megahan, p. 312.

[45] FM 100-5, p. 2-15.

[46] U.S Army, The Armor Center and School, IVIS Operational Concept (Fort Knox, KY: U.S. Army Armor Center, 1992), p. ix.

[47] Draft "Battle Command Concept," pp. 15-16, 18.

[48] Ibid., p. 17

[49] Major Harvey A Teston, Jr., "Command and Confusion at the NTC," Military Review (November, 1985), pp. 62-63.

[50] Richard E. Simpkin, Tank Warfare: An Analysis of Soviet and NATO Tank Philosophy (London, England: Brasseys Ltd., 1979), p. 127.

[51] Orr Kelly, King of the Killing Zone (New York, NY: W.W. Norton, 1989), p. 213. Mr. Kelly writes about the development of the M1A1 MBT. He notes that it was six years, eight months after the formation of a U.S. Army special task force, charged with developing the requirements for a replacement of the M-60 series tank, before the first production M-1 tanks rolled off the assembly line. If one considers early, failed attempts to develop a suitable replacement (such as the MBT-70, a joint U.S. - German effort), then the time is as long as 17 years.

[52] T.W. Terry, S.R. Jackson, C.E.S. Ryley, B.E. Jones, and P.J.H. Wormell, Fighting Vehicles, Brassey's New Battlefield Weapons Systems and Technology Series, vol. 7, Land Warfare, ed. Frank Hartley (London, England: Brassey's Ltd., 1991), p. 279.

[53] Terry, p. 15.

[54] Peter Gudgin, Armour 2000 (London, England: Arms and Armour Press, 1990), p, 41.

[55] "We Have a Winner!," Armor (July-August, 1993), pp. 7-8. The design for the "model FMBT" used in this monograph is the first place winner of the joint Armor Association/U.S. Army Armor Center sponsored tank design contest. The Western Design Corporation FMBT provides the baseline model for the study. I have added some additional detail, when necessary, on other aspects of the FMBT not included in the winning entrant. This detail is based on research of the Army's proposed FMBT variant under the Armored Systems Modernization (ASM) Program, and my own knowledge of emerging technologies that will be included on the FMBT around the 2005 to 2010 time frame. My expertise in this area is based on two years service with the Directorate of Combat Developments, U.S. Army Armor School. During that time, I served as the Chief, Command, Control, Communications and Computers (C4) Branch, project officer for the M1A2 tank's command and control system, the Intervehicular Information System (IVIS), and as a member of the Program Executive Officer for Armored Systems Modernization (PEO ASM) sponsored "user jury" for the FMBT/Common Chassis Components Advanced Technology Test Bed (CATTB) program. All information included in this monograph is unclassified and nonproprietary.

[56] Captain Edward W. Payne, "The Army's Key Emerging Technologies," Armor (March-April, 1992), p. 10.

[57] Ibid., p. 7. Brassey's Fighting Vehicles describes various types of passive armor. See pages 130-134.

[58] Terry, p. 153.

[59] "We Have a Winner," p. 9. A shadow diagram provides some comparison of the FMBT silhouette with that of the M1 tank.

[60] Payne, p. 7.

[61] Terry, pp. 102 and 152.

[62] See diagram, Appendix A.

[63] "CATTB Future Tank Demonstrator Takes Shape," International Defense Review, vol 23 (December, 1990), p. 1411. Also, see Terry, p. 137.

[64] Gudgin, p. 66.

[65] "CATTB Future Tank Demonstrator Takes Shape," pp. 1411-1412.

[66] Payne, p. 11. Figure 13 in Payne's article shows the following payoffs from the use of the Advanced Integrated Propulsion System (AIPS): reduced hull weight/volume (25%), range (30%), mobility (50%), increased design flexibility (100%), increased burst power (50%), diagnostics and prognostics (100%), and improved platform stability (30%).

[67] See "Armored Systems Modernization Capstone Required Operational Capabilities," pp. 1-35 and 1-41.

[68] Ibid., p. 1-34.

[69] Ibid., p. 1-35.

[70] Ibid., p. 1-35.

[71] Ibid., p. 1-35.

[72] Ibid., p. 1-36.

[73] Ibid., p. 1-36.

[74] Ibid., pp. 1-42 to 1-54.

[75] Major General Paul E. Funk, "The Right Technology at the Right Time," Armor (May-June, 1993), p. 5. At the time of this writing MG Funk was the commander of the U.S. Army Armor Center and Commandant of the U.S. Army Armor School. Much of the work for the battle command system for

the M1A2 and the FMBT is currently being conducted at the Armor Center's mounted warfighting battlelab. In fact, the Armor Center has been conducting experiments in this area using both simulation technology and low scale prototypes for the last 10 years.

[76] U.S. Army, U.S. Army Armor Center, IVIS Operational Concept (Fort Knox, KY: July, 1992), pp. 9-20. This paper provides explicit detail on how the M1A2 IVIS and CVC2 system may be used on the horizontally and vertically integrated future battlefield by tank commanders at levels battalion and below.

[77] IVIS Operational Concept, p. v.

[78] Funk, p. 35.

[79] John Rhea, "Vetronics: The First Generation," Army (May, 1991), p. 44.

[80] "Armored Systems Modernization Capstone Required Operational Capabilities," p. 1-34.

[81] Ian Bustin, "Vetronics-The Quiet Revolution for Armoured Vehicles," Military Technology (May, 1992), p. 82.

[82] Mountcastle, p. 37.

[83] Terry, p. 139.

[84] Appendix 7 (Systems Retained in Design) to Chapter 5 (Capstone ASM Requirements) in the ASM ROC specifies a Command Group Vehicle (CGV) with vehicle signature similar to the Future Infantry Fighting Vehicle (FIFV). In an armor pure formation, or even in an armor heavy combined arms task force, this may not provide sufficient signature reduction for the armored task force commander. The flexibility of design that SAVA provides to ASM makes it just as feasible to reconfigure a FMBT hull and turret to meet the commander's needs as it is to do the same for the FIFV.

[85] Jon L. Boyes and Stephen J. Andriole, eds., Principles of Command and Control (Washington, D.C.: AFCEA International Press, 1987), p. 182.

[86] Simpkin, Human Factors in Mechanized Warfare, p. 47.

[87] Field Manual 71-2, p. 2-9.

[88] James P. Kahan, D. Robert Worley, and Cathleen Stasz, Understanding Commander's Information Needs (Santa Monica, CA: RAND Corporation, 1989), pp. vii, 9, 30, 93.

[89] Simpkin, Human Factors in Mechanized Warfare, pp. 47-48. Additionally, the Command Group Vehicle in Appendix 7 (Systems Retained in Design) to Chapter 5 (Capstone ASM Requirements) in the Draft Armored Systems Modernization Required Operational Capabilities (ASM ROC) conceptually has seating and workstations for three plus the crew, which I assume to be at least a driver, gunner, and tactical commander. General Frederick J. Kroesen states in an article that the command group should consist of intelligence, operations, and fire support officers, and that each should have the mobility, security, and communications equal to that of the commander. See "What Should a Command Post Do?" Military Review (January, 1993), p. 35.

[90] B. E. Furby and V.J. Demczuk, "Human Factors in Command and Control," Pacific Defense Reporter (February, 1989), p. 49.

[91] Terry, p. 120.

[92] IVIS Operational Concept, pp. 2-3. This concept provides a basis for Vehicle Control and Operating System (VCOS) functional information sharing within the FMBT and the future armored force at battalion and below. Also see requirement for VCOS to interface, download, and reference current and future DOD/DA standard C2 software applications in the ASM ROC, p. 1-39.

[93] Bustin, p. 86.

[94] Mountcastle, p. 39.

[95] The draft ROC for the FMBT does not discuss the possibility of a multifunctional tank. Also interesting is the fact that the M1A2 tank contains the first generation of the battle command system and the electronics architecture that the Army envisions for ASM. The IVIS Operational Concept addresses how the armored task force commander might use his on-board battle command system to enhance his situational awareness. However, there has been no effort on the part of the Army to investigate the possibility of a developing a near-term Command Group Vehicle using the M1A2 as a prototype vehicle. General Dynamics Land Systems, the prime contractor for the production of the M1A2, recently developed four design concepts for a CGV that would use the M1A2 as its baseline platform. However, without the development of a VIDS for the M1A2, the tank must still mount a main gun for protection and survivability.

The space required for the gun and its ammunition limits the number of ancillary staff that the commander can host on his tank. Most of the Army's current research and development efforts looking at a future CGV for the commander are using the Battle Command Vehicle (BCV) as the concept development prototype. The BCV is a shelter mounted on a Bradley/Multiple Launch Rocket System chassis. The interior of the vehicle will be modified to include workstations for staff members and the commander. See the Combined Arms Command's Command and Control Vehicle Operations Concept (Final Draft) for further definition of the BCV.

96 See "U.S. Army Armor and Engineer Board Command and Control Vehicle Concept Evaluation Program." Modifications were made to the Bradley Fighting Vehicle, M60A3 tank, and the M1 tank in order to determine feasibility of using these vehicles as command and control platforms for company and battalion commanders.

97 David Eshel, "Trends in Future Tank Developments," Military Technology (October, 1992), pp. 16-18.

98 Ludvigsen, p. 35.

99 Randall Steeb, Keith Brendley, Dan Norton, John Bondanella, Richard Salter, and Terrell G. Covington, An Exploration of Integrated Ground Weapons Concepts for Armor/Anti-Armor Missions (Santa Monica, CA: RAND Corporation, 1991), pp. 178-179.

100 Ibid., pp. 177-178.

101 We Have a Winner!," pp.7, 8. The pictures of the FMBT in Appendix A are taken from Armor magazine. They represent the Western Design Corporation's submission to the Armor Association and U. S. Army Armor Center jointly-sponsored tank design contest. Note: material may be reprinted, provided credit is given to Armor and to the author, except where copyright is indicated.

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